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Plate Removal and Risk Factors Contributing to Plate-Related Complications following Rigid Fixation in Maxillofacial Surgery: A Retrospective Study

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Abstract

Background and objectives: Internal fixation is the preferred method for craniomaxillofacial, orthognathic and reconstructive surgeries. However, it can lead to complications, which may vary depending on the type of surgery and patient demographics. Common complications include screw loosening, plate breakage and infections. For instance, infections may be more prevalent in patients with pre-existing conditions or those undergoing complex reconstructive procedures, while plate breakage might be more frequent in high-impact trauma cases. This study aimed to investigate the causes and factors related to plate removal surgery in Iran.

Materials and methods: This retrospective study investigated the prevalence and causes of titanium plate removal in patients who underwent plate removal surgery between 2019 and 2023 in two hospitals in Tehran, Iran. Data were collected from registered electronic files, with a focus on the date and cause of plate insertion and removal, the time interval between these events, and the demographic profiles of the patients, and the data were analyzed using descriptive statistics.

Results: A total of 1,776 patients were included in the study, with a plate removal rate of 4.3%. The participants who underwent plate removal were mostly males (n = 44; 57.9%) with a mean age of 32.7 ± 16.6 years. The patients were categorized into five groups on the basis of the reason for plate placement: trauma, pathology, orthosurgery, esthetics and cleft. The median duration of plate placement was 14 months, with infection being the primary cause of early removal. Most of the removed plates were located in the mandible, with the highest concentrations in the angle and body areas.

Conclusion: This study revealed a low frequency of plate removal, primarily due to infections, with variations observed by age and sex. It is recommended that future large-scale, multicenter studies with extended follow-up periods be conducted to gain a deeper understanding of the epidemiology, risk factors, causes, and complications associated with plate removal.

Keywords: Craniomaxillofacial surgery; Internal fixation; Plate removal; Titanium plates; Infection.

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1. Introduction

Internal fixation is currently the preferred method for craniomaxillofacial, orthognathic and reconstructive surgeries (1). Reconstruction of maxillofacial defects and fixation of

bone fragments are necessary for cases such as trauma, orthognathic surgeries, and defects caused by pathological lesions (2). Internal fixation methods using macroplates, miniplates, and microplates provide the best results for maxillofacial trauma (3). Jaw reconstruction after tumor resection is essential for function and aesthetics. Reconstruction plates are used when bone reconstruction is not feasible (4).

Placing plates can lead to complications, such as screw loosening and breakage, plate palpability, plate breakage, plate exposure and infections that may require surgery to remove the plate. Plate infections can cause abscess formation, fistula, and osteomyelitis (3). Several factors, including primary diagnosis, type of reconstruction (whether performed immediately during the initial surgery, known as primary reconstruction, or at a later time, referred to as secondary reconstruction), previous radiotherapy, smoking, diabetes, extent of osteotomy, extent and location of the craniofacial defect, infection, and associated soft tissue defect can be linked to plate-related complications (5).

Some surgeons advocate removing the plate with a second-stage surgery, while others recommend plate removal only in cases of clinical symptoms. Reports on the extent of plate removal vary worldwide, with removal rates of mini- plates ranging from 6% to 40%. There is no consensus on removing all plates in universities and medical centers in Iran (1). Plate removal surgery can cause problems for patients in terms of aesthetics, performance and cost. The purpose of this study was to investigate patients who underwent plate removal surgery, the causes of plate removal, and the related factors, given the lack of information about the cause and epidemiology of plate removal and plate-related complications in the Maxillofacial Surgery Department of Tehran University of Medical Sciences. The results of this study can be used to reduce the possibility of needing surgery to remove the plate.

2. Materials and methods

This retrospective study aimed to investigate the prevalence and causes of titanium plate removal in patients who underwent plate removal surgery for any reason. This retrospective study investigated the surgeries performed in two hospital centers Shariati and Sina in Tehran, Iran from March 2019 to February 2024. Data collection was conducted by accessing registered electronic files, excluding patients whose medical records were not fully recorded.

The study observed the correctness of transferring the information obtained from the files to the research while maintaining trust in the patient and surgeon profiles. The final analysis included patients who underwent plate removal, and exclusion criteria were applied to ensure the integrity of the data. Specifically, patients were excluded from the study if they had incomplete medical records regarding the plate insertion or removal, had significant comorbidities such as severe osteoporosis, uncontrolled diabetes, or chronic infections, were lost to follow-up, or had non-standard or experimental plate types. The data extracted included the date and cause of plate insertion and removal, the time interval between plate placement and removal, and the demographic findings of the patients. The data that were collected were presented using descriptive statistics.

3. Results

A total of 1776 patients were included. Seventy-six participants (4.3%) had plate removal. The participants who underwent plate removal were mostly males (n = 44; 57.9%) with a mean age of 32.7 ± 16.6 years (Figure 1).

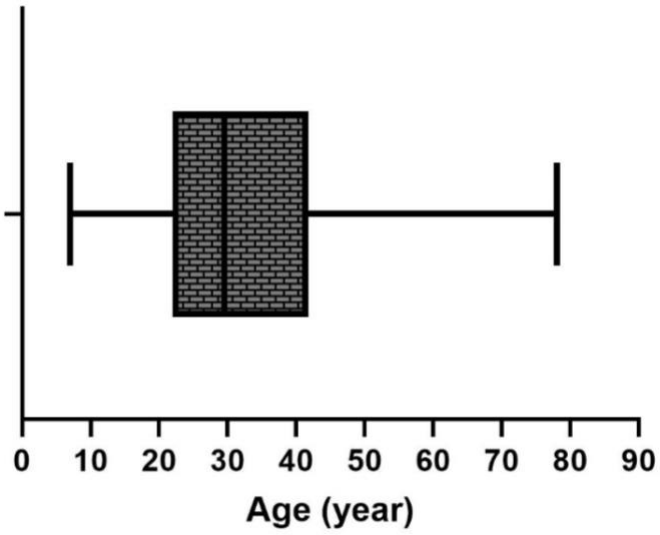

Figure 1. Box plot representing the age distribution of the participants.

The patients were divided into five groups on the basis of the indication for placing the plate: trauma, pathology, orthosurgery, esthetics and cleft. Among males, trauma (n = 27; 61.4%), followed by pathology (n = 11; 25.0%), orthosurgery (n = 4; 9.1%), esthetics (n = 1; 2.3%) and cleft (n = 1; 2.3%) were the most common indications for plate placement among participants (Table 1). Early removal was primarily due to infection (n = 32; 42.1%), followed by exposure (n = 17; 22.4%), pain (n = 7; 9.2%), developmental interference (n = 6; 7.9%), plate fracture (n = 4; 5.3%) and implant interference (n = 3; 3.9%) (Figure 2). The median duration of plate placement was 14 months (Figure 3).

Most of the removed plates were located in the mandible. Specifically 36.17% were in the angle area, 31.91% were in the body , 19.14% were in the para-symphysis, and 12.76% were in the symphysis.

Table 1. The clinical characteristics of the participants, by anatomic region and indication for plate placement

	Cleft	Esthetic	Orthosurgery	Pathology	Trauma
Maxilla	2 (28.6%)	0	4 (57.1%)	0	1 (14.3%)
Mandible	0	3 (5.3%)	7 (12.3%)	18 (31.6%)	29 (50.9%)
Zygomaticomaxillary complex	0	0	0	0	11 (100.0%)
Frontotemporal	0	0	0	1 (100.0%)	0

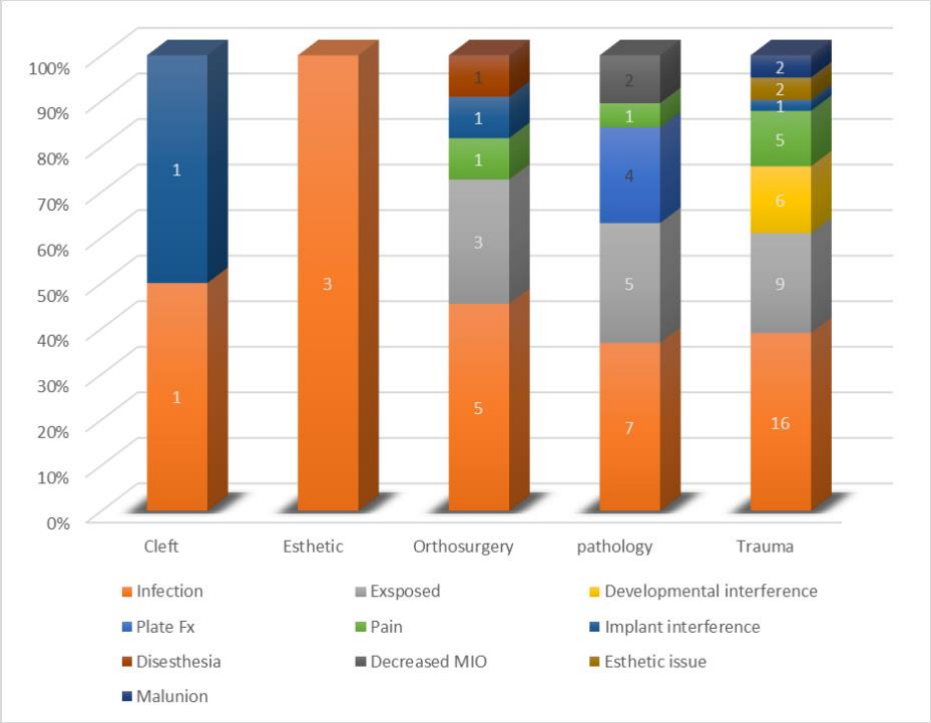

Figure 2. The indications for plate removal among the participants. The number inside each column represents the count of participants who underwent plate removal for the specific reason denoted by the corresponding color. The colors in the columns reflect different indications for plate removal, as detailed in the figure legend. Each color-coded segment within the columns represents a distinct reason for the procedure, facilitating a clear understanding of the distribution of indications among the participants.

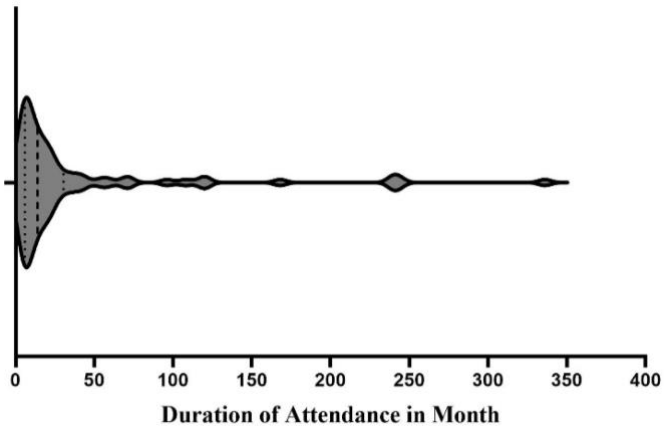

Figure 3. Duration of plate presence.

4. Discussion

The findings of our study revealed an overall plate removal rate of 4.3%, with infection being the most common cause. The median duration before removal was 14 months. The angle of mandible was the most frequent location for the plates.

Among the reasons for plate removal, the most common cause in our study was infection, followed by exposure and pain. Similarly, Gómez-Barrachina et al. reported infection as the most frequent cause in 6.6% of cases, followed by plate exposure (2.6%), thermal sensitivity (2.1%), screw issues (2.0%), and pain or tenderness (1.9%) (6). Another meta-analysis of 10 studies involving 1603 participants revealed

infection (2.9%), exposure (0.6%), and palpable plates (0.4%) as the most common causes of miniplate removal (7). Similarly, another case-control study in Iran involving 97 cases who underwentplate removal surgeries reported infection and plate exposure as the most common causes of plate removal (1). Plates in submucosal tissues are vulnerable to environmental trauma and the mechanical stresses of chewing. These factors can decrease their stability, cause screw loosening, trigger an increase the risk of infection and inflammation (8). If an infection occurs within the first six weeks after the fixation, conservative treatment with pus drainage and antibiotics may be adequate to support fracture healing while keeping bone fixation in place. Once the fracture is stable, the plate can be removed. However, if the infection spreads to the underlying bone and the bone has not fully united, it may be necessary to remove the plate and proceed with external fixation and bone grafting (8). Long-term antibiotic prophylaxis is recommended for the prevention of infections after orthognathic surgeries, as it can reduce the risk of surgical site infections by 58% (9). In this context, penicillin and amoxicillin are frequently prescribed because the bacteria commonly responsible for infections in oral and maxillofacial surgery are susceptible to these antibiotics (10).

The study by Fani et al. reported a mean duration of 12.9 months from plate placement to removal and a male to female ratio of 1.54 (1). In addition, the reasons for plate removal were trauma, pathological lesions, and orthognathic surgeries in decreasing order of frequency (1). In our study, the median duration of plate placement to removal was higher than that in the abovementioned study (14.0 vs. 12.9 months). This discrepancy can be explained by variations in the demographic characteristics of the participants, such as age and sex, and the reporting of two different measures (i.e., mean and median) for the time period. However, consistent with that study, trauma and pathological lesions, followed by orthognathic and aesthetic surgeries, were the most common reasons for plate removal. The frequency of male patients differed depending on the reason for surgery. For plate removal surgeries due to trauma and pathological lesions, the number of males exceeded that of females, while there were more cases of females for orthognathic and aesthetic reasons in our study. Additionally, the highest number of plate removals occurred in the first two to three decades of life. The article by Daniels et al. revealed that the 16-30 year (45.6%) and 0-15 year (28.8%) age groups had the highest frequency of plate removal (11). For pediatric patients, researchers suggest removing miniplates within 2-3 months after the fracture has healed to prevent potential growth restrictions. Therefore, they recommend the use of resorbable plates and screws for managing facial fractures in children (12).

With respect to the location of the removed plates, the mandible was the mostcommon location, followed by the Zygomaticomaxillary Complex (ZMC), maxilla and frontotemporal area. In accordance with our findings, a retrospective review of 76 cases who were followed for 10 years showed that 3.7% of the plates were removed; these plates were placed in the mandibular symphysis and mandible angle (13). Similarly, another observational study of 149 patients who underwent miniplate or screw removal showed that the mandibular angle and parasymphyseal sites were the most common areas of miniplate removal, accounting for 22.8% and 14.1% of cases, respectively (11). In this regard, another systematic review and meta-analysis of 11 studies with 2240 patients indicated that the mandible in 72.8% of cases was the most frequent site of removal, particularly in the symphysis and the angle (8). The observed trend toward the removal of plates from the mandible might be attributed to the structure of mandible's denser cortical bone in comparison with other facial bones. Furthermore, the mandible's primary blood supply comes from the inferior alveolar artery and the periosteum, both of which are vulnerable to injury during trauma and surgical interventions (14).

The results of a systematic review and meta-analysis of 19 studies showed that the frequencies of individuals who needed plate removal and plate removal were 13.4% (95% confidence interval (CI): 9.6, 18.3%) and 9.7% (95% CI: 6.3, 14.6%), respectively (6). In another study of 76 patients, this frequency was 3.7% (13) The meta-analysis by Jaber et al. showed that only 294 out of 5595 miniplates (5.3%) required removal (7). Generally, the prevalence of plate removal is low, as the studies indicated. Our study also showed that 4.3% of patients needed plate removal. The differences between the studies might be explained by variations in the reasons for plate removal, differences in the age of participants, complications, and duration of plate placement.

The study has several limitations that should be considered. The classification of complications and the need for plate removal were not based on the brand of the plates or other factors such as smoking status or alcohol consumption. Additionally, selection bias is unavoidable in this study due to its non-randomized controlled trial design. There is also a risk of sampling bias resulting from the use of the convenience sampling method. Furthermore, this is a descriptive retrospective study based on medical records from two hospitals, so the findings might not be generalizable to other populations.

5. Limitations

Due to the retrospective nature of the study, there was no access to intraoperative details, including the duration of the operation, length of hospitalization, and the type of antibiotic prescribed. In addition, some details about the patients such as the history of smoking and their exact amounts could be effective as a strong risk factor.

6. Conclusion

In summary, plate removal was infrequent, suggesting it may not be necessary for all patients. The primary reason for removal was infection, with variations potentially influenced by age and sex. To improve our understanding, future research should involve large-scale, multicenter studies with extended follow-up periods to find long-term outcomes and complications. It is necessary to investigate specific risk factors associated with the need for plate removal and explore how age and sex influence these outcomes. Additionally, evaluating alternative approaches to reduce the necessity of plate removal or improve management of complications could provide valuable insights.

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Ethics

The current study was approved by the Research Ethics Committees of Amir A'lam Hospital Complex on June 11, 2023 (ethical code: IR.TUMS.AMIRALAM.REC.1402.019).

Author contributions

Zahra Sadat Modarresi: Conceptualization, Methodology, Investigation, Data curation, Visualization , Writing - Original draft.
Zeinab Bakhtiari: Formal analysis, Investigation, Data curation, Visualization, Writing - Original draft.
Mina Khavamzadeh: Formal analysis, Writing - Review & editing.
Farnoosh Razmara: Conceptualization, Methodology, Resources, Writing - Review & editing , Supervision.

Conflict of interest

The authors declare no conflicts of interest.

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